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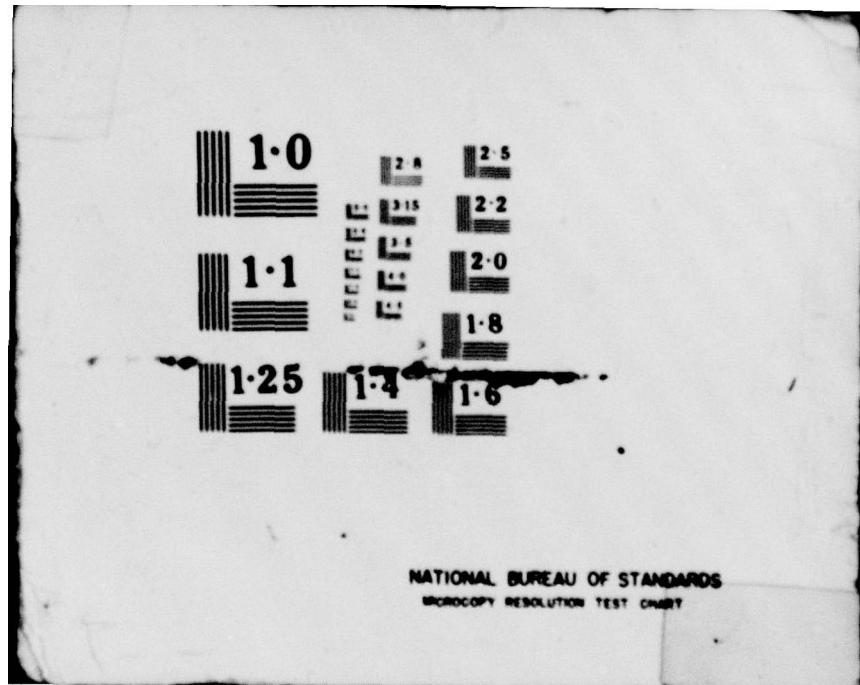
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Report No. FAA-RD-78-182

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FAA LIGHTNING PROTECTION STUDY: REPORT OF
INVESTIGATIONS RELATIVE TO PROVIDING LIGHTNING
PROTECTION FOR CONTROL LINES FOR THE REMOTE CENTER
AIR-TO-GROUND (RCAS)

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Richard M. Cosey



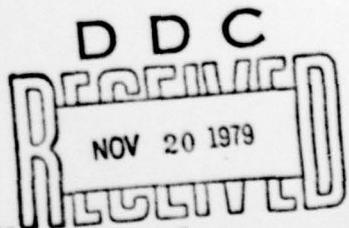
May 1978

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16. Abstract The purpose of the Lightning Protection Study is to determine the degree of susceptibility of FAA electronic systems to induced electromagnetic pulse effects due to lightning and to propose protective devices adequate for low voltage solid state systems. This Report covers the RCAG. While the RCAG does contain solid state circuitry with potentially susceptible components, they are sufficiently isolated from transients so that effects are apparently negligible. Two separate reviews of four RCAG's in Florida failed to surface any outages directly attributable to lightning induced transients on control lines.	12/14 309050 LM		
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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	What You Know	What by	To Find	Symbol	What You Know	What by	To Find
LENGTH							
inches	12.0	centimeters	centimeters	millimeters	0.03	feet	0.3048
feet	30	centimeters	centimeters	centimeters	0.4	inches	3.048
yards	0.9	centimeters	centimeters	centimeters	1.1	feet	0.9144
miles	1.6	centimeters	centimeters	centimeters	0.4	yards	1.0936
AREA							
square inches	144	square centimeters	centimeters	square centimeters	0.16	square feet	1.0
square feet	10	square centimeters	centimeters	square centimeters	1.2	square yards	1.196
square yards	900	square centimeters	centimeters	square centimeters	6.4	square miles	1.196e+006
square miles	1.6	square centimeters	centimeters	square centimeters	2.5	square kilometers	1.0e+006
MASS (weight)							
ounces	28.35	grams	grams	grams	0.035	pounds	1.0
ounces	16	grams	grams	grams	0.2835	kilograms	0.035
pounds	16	grams	grams	grams	2.2	tonnes	0.035
short tons	(2000 lb)	grams	grams	grams	1.1	metric tonnes	0.035
VOLUME							
cubic inches	16	cubic centimeters	centimeters	cubic centimeters	0.03	cubic feet	1.0
cubic feet	16	cubic centimeters	centimeters	cubic centimeters	2.1	cubic yards	1.196
cubic yards	16	cubic centimeters	centimeters	cubic centimeters	6.4	cubic miles	1.196e+006
cubic miles	1.6	cubic centimeters	centimeters	cubic centimeters	1.2	cubic kilometers	1.0e+006
TEMPERATURE (°F to °C)							
°Fahrenheit	57.2	°Celsius	°Celsius	°Celsius	9.5 (from and 32)	°Fahrenheit	50
°Fahrenheit	-40	°Celsius	°Celsius	°Celsius	32	°Fahrenheit	-40
TEMPERATURE (°C to °F)							
°Celsius	10	°Fahrenheit	°Fahrenheit	°Fahrenheit	50	°Celsius	15
°Celsius	0	°Fahrenheit	°Fahrenheit	°Fahrenheit	32	°Celsius	0
CONVERTING UNITS							
For other units, consult tables and charts in the back of this book. See also U.S. Government Circular 107, "Metric Conversion Tables," U.S. Office of New Words and Measurements, P.O. Box 12-25, 50 Constitution Ave., N.W., Washington, D.C. 20585.							

Approximate Conversions from Metric Measures

Symbol	What You Know	What by	To Find	Symbol	What You Know	What by	To Find
LENGTH							
millimeters	0.03	centimeters	centimeters	centimeters	12.0	inches	1.6
centimeters	0.4	centimeters	centimeters	centimeters	30	feet	0.9144
centimeters	1.1	centimeters	centimeters	centimeters	900	yards	0.9144
centimeters	0.9144	centimeters	centimeters	centimeters	1.6	miles	0.0009144
AREA							
square centimeters	0.16	square millimeters	millimeters	square millimeters	144	square inches	16
square centimeters	1.2	square millimeters	millimeters	square millimeters	10	square feet	16
square centimeters	6.4	square millimeters	millimeters	square millimeters	16	square yards	6.4
square centimeters	1.0e+006	square millimeters	millimeters	square millimeters	1.6e+006	square miles	1.0e+006
MASS (weight)							
grams	0.035	ounces	ounces	ounces	28.35	pounds	16
grams	0.2835	ounces	ounces	ounces	16	short tons	16
grams	0.035	ounces	ounces	ounces	1.0	tonnes	1.0
grams	0.035	ounces	ounces	ounces	0.035	metric tonnes	1.0
VOLUME							
cubic centimeters	0.03	cubic millimeters	millimeters	cubic millimeters	16	cubic inches	16
cubic centimeters	2.1	cubic millimeters	millimeters	cubic millimeters	10	cubic feet	2.1
cubic centimeters	6.4	cubic millimeters	millimeters	cubic millimeters	16	cubic yards	6.4
cubic centimeters	1.0e+006	cubic millimeters	millimeters	cubic millimeters	1.6e+006	cubic miles	1.0e+006
TEMPERATURE (°C to °F)							
°Celsius	9.5 (from and 32)	°Fahrenheit	°Fahrenheit	°Fahrenheit	50	°Celsius	15
°Celsius	32	°Fahrenheit	°Fahrenheit	°Fahrenheit	10	°Celsius	0
TEMPERATURE (°F to °C)							
°Fahrenheit	50	°Celsius	°Celsius	°Celsius	0	°Fahrenheit	32
°Fahrenheit	10	°Celsius	°Celsius	°Celsius	-40	°Fahrenheit	-40

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This report covers the investigation of the susceptibility to damage from lightning induced transients to the Remote Center Air-to-Ground (RCAG) facilities. The study has been part of a larger study program to provide protection for communications electronic equipment belonging to the FAA and conducted under the Post Doctoral Program.

Investigation of the susceptibility to damage from lightning induced transients of Remote Center Air/Ground Facilities (RCAG) has been part of a larger study program to provide protection for communications electronic equipment.

Generally, newer solid state equipments, operating at much lower voltage levels than vacuum tube equipments have shown increased sensitivity to transients induced on both power and control lines causing problems ranging from complete failure to faulty and misleading data outputs. Certain Instrument Landing System (ILS) remoting circuits with control lines directly interfacing solid state components were found to be particularly susceptible. A series of reports summarized in Reference 1 have documented the problems and specific recommended solutions.

The Remote Center Air/Ground System (RCAG) is one of the two types of facilities in the enroute air/ground (A/G) VHF/UHF communication system. A typical installation is shown in Figure 1A, and its system function block diagram in Figure 2. It provides a medium of communication between a controller and pilot for air traffic control purposes. It has the following general characteristics:

1. The system is designed to transmit and receive double sideband amplitude modulated voice signals with an audio bandwidth of approximately 3000 cps.
2. The RF channel bandwidth is 50 to 100 kc for VHF service and 100 kc for UHF service.
3. The radio frequency bands for air/ground communications are 118-136 mc for civil aviation service and 225-400 mc for military service.



Figure 1A. A Typical RCAG Installation (Melbourne, Florida)

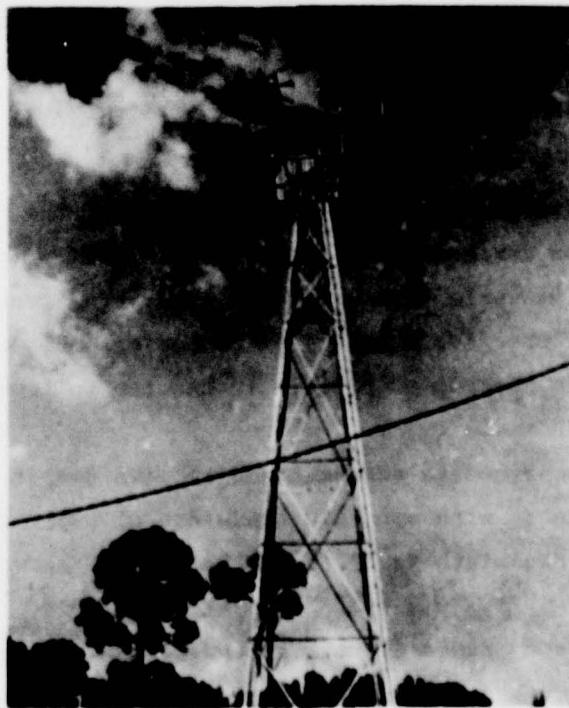


Figure 1B. Typical RCAG Antenna System Tower. In general there are four towers in each RCAG facility. (Melbourne, Florida)

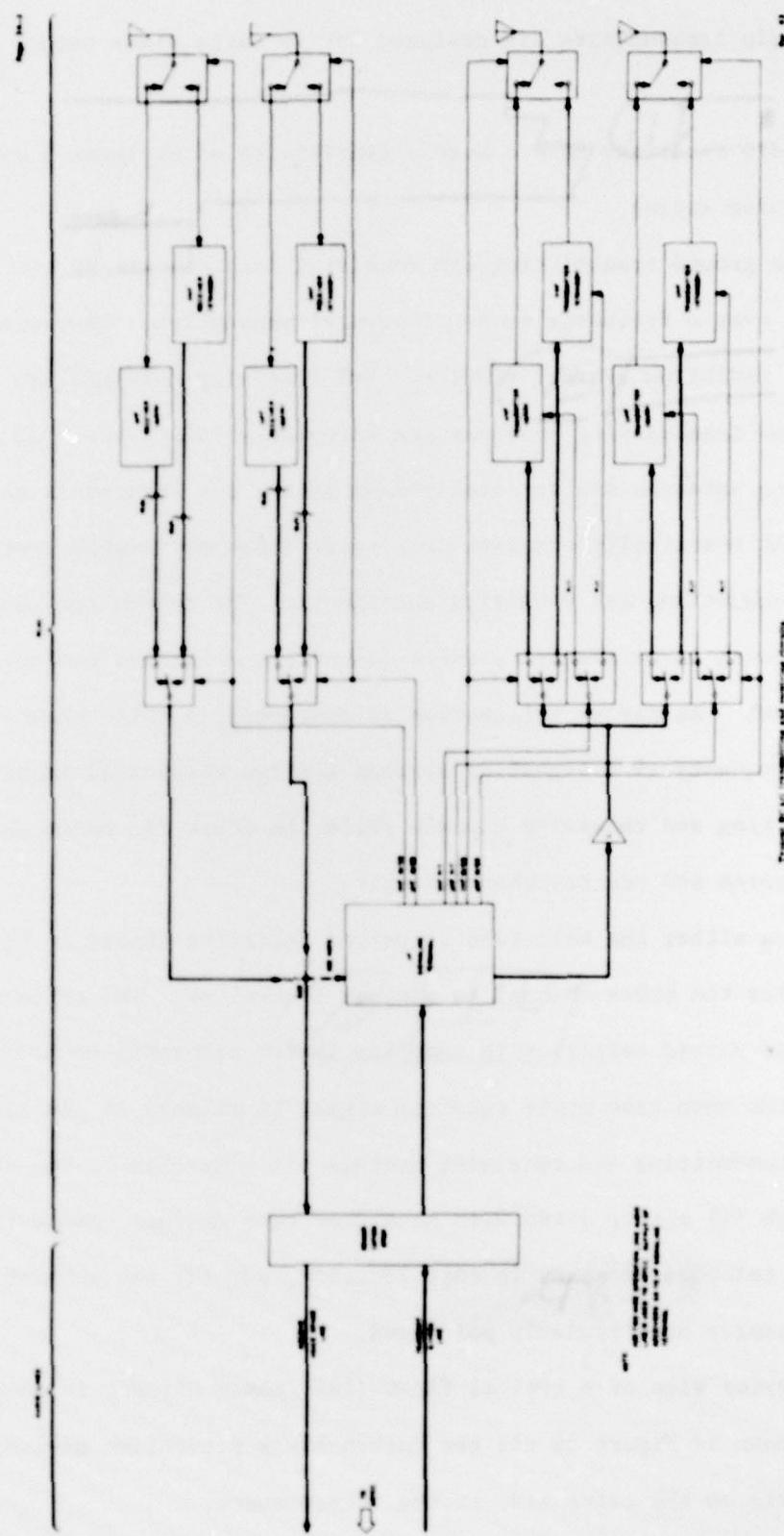


Figure 2. Typical RCAG Transmitting and Receiving Circuits

4. Radio transmitters are designed for 10 watts power output or optional 50 watts.

5. Radio receivers have a usable sensitivity of at least 5 μ v (at 10-dB signal to noise ratio).

6. The ground transmitting and receiving antennas are of the broadband type useful over a frequency range of several megacycles. They also have omnidirectional radiation characteristics. VHF receiving antennas are vertically polarized and transmitting antennas are circularly polarized. UHF transmitting and receiving antennas are vertically polarized. See Figures 1A and B.

The RCAG essentially consists of a voice frequency signal system and separate transmitting and receiving equipments. The system can operate in one of the following three modes: a split channel, a selective channel, and a paired channel. As far as utilization is concerned, a split channel must use two voice frequency (VF) signaling systems and two FAA-S-1142 telephone circuits for transmitting and receiving signals while the other two modes use one VF signaling system and one telephone circuit.

In using either the selective or paired selective channels, keying one channel denies the other channel to another controller. The difference between selective and paired selective is that the latter transmits both VHF and UHF signals at the same time while only one signal is allowed in the first case.

Both transmitting and receiving systems are connected to the outside world through (1) either a two wire or a four wire circuit, which is leased to FAA by a telephone company in that locality, and (2) the antennas which are either vertically or circularly polarized.

An exterior view of a typical FAA-S-1142 leased circuit is shown in Figure 3A. Also shown in Figure 3B are the carbon-block protective devices in the terminal strip on the telco side of the interconnect.



Figure 3A. Exterior View of a Typical FAA-S-1142 Circuit Terminal

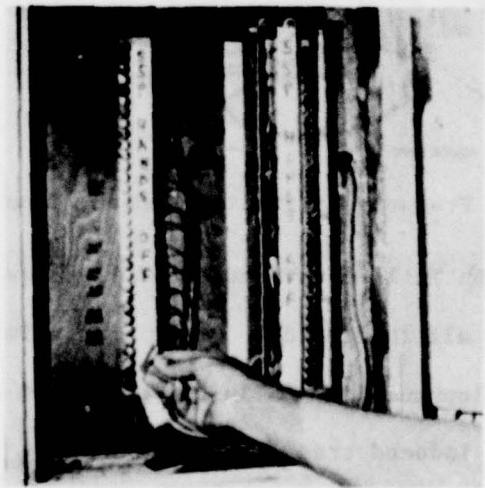


Figure 3B. Interior View of the Terminal Showing Carbon Block Holders (Vertical Strip, Right Side)

During the time frame that the overall investigation were taking place, the FAA was in the process of upgrading RCAG installations in the Southern Region. The existing tube type equipments were being replaced by new, largely solid state equipments. The receivers and 10 watt transmitters are completely solid state and only where 50 watt amplifiers are installed are any vacuum tubes used. Hence the word 'largely'. Specifically, these equipments, either in use or being installed were:

Voice Frequency Signaling System, FA-8187 (4) Figure 4.

Transmitting Set, Radio AN/GRT-21 (VHF) consisting of Transmitter, Radio T-1108/GRT-21, the exciter and amplifier and Amplifier, Radio Frequency, AM-6154/GRT-21, the power amplifier (2) Figure 5.

Transmitting Set, Radio AN/GRT-22 (UHF) consisting of Transmitter, Radio T-1109/GRT-22, the exciter and amplifier and Amplifier, Radio Frequency, AM-6155/GRT-22, the power amplifier (2) Figure 5.

(In both cases where only 10 watt output is required, the power amplifier is not used.)

Receiver, Radio, AN/GRR-23 (VHF) (3) Figure 6.

Receiver, Radio, AN/GRR-24 (UHF) (3) Figure 6.

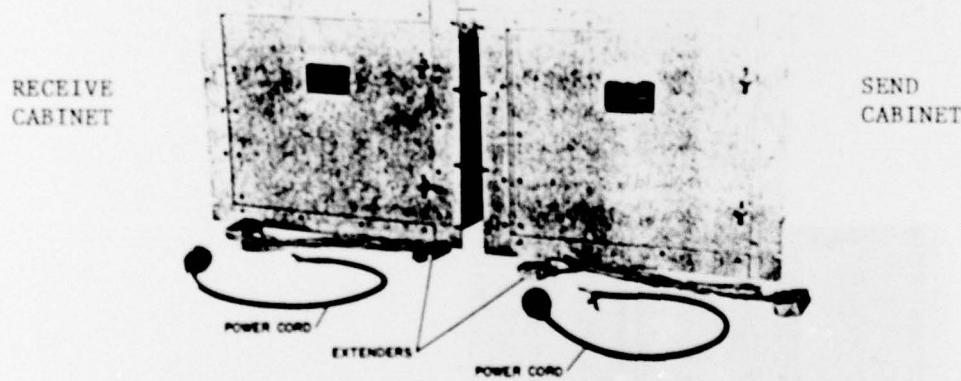
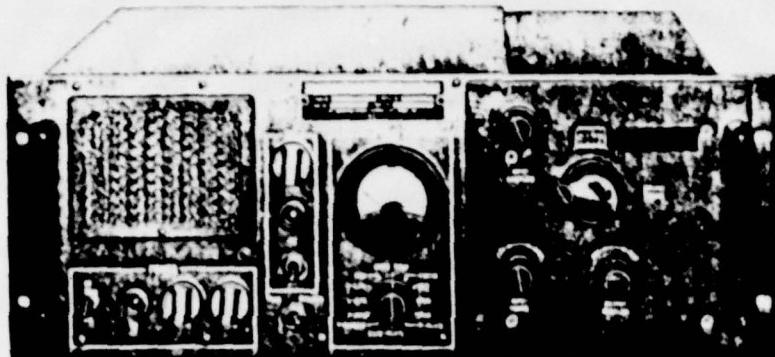


Figure 4. Voice Frequency Signaling System, Type FA-8187

The RCAG investigation begun in 1975 covered Miami (two installations), West Palm Beach, and Melbourne, all in Florida. Other than primary power failures, or external telephone line failures, no record of outages directly attributable lightning induced transients were found.



Amplifier, Radio Frequency, AN-6154/GRT-21 and AN-6155/GRT-22



Transmitter, Radio, T-1108S/GRT-21 and T-1109S/GRT-22

Figure 5. Transmitting Set, Radio AN/GRT-21 and AN/GRT-22

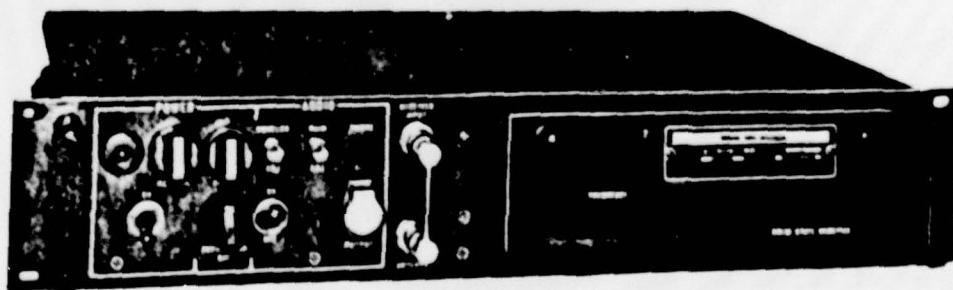


Figure 6. Receivers, AN/GRR-23 and AN/GRR-24

It should be noted, however, that experience with the new equipment was limited. Installation at Melbourne was just underway at that time. A paper analysis of susceptibility indicated no problem. However, it was felt that rather than a negative report, the problem should be given a reasonable time to assert itself. A review was made again in May 1979. The same stations were contacted and again a negative report was received. Negative evidence notwithstanding, during this interim period, change 234 to AF P 6500.1 (Communications Facilities and Equipment Modification Handbook - General) dated 7/28/76 was issued by FAA, AAF. (5) Chapter 279 is a modification to "Provide Lightning Surge Protection Circuits for Control Lines at Remote Center Air-to-Ground (RCAG) Facilities."

This change, directive in nature, states this modification applies to all RCAG facilities. In the background paragraph the change notes that "The RCAG contains equipment susceptible to damage by transients. Many component failures and facility outages have been traced to lightning strikes, which induce abnormally high voltage transients onto control lines. Damage can be minimized by installation of lightning protection circuits (LPC's) between FAA equipment and the telephone company (telco) demarcation terminal strip."

Actually all solid state devices are susceptible. However, the nature of the RCAG installation itself and the design of the equipment in this case tends to provide protection against all but a direct strike. Incoming lines have the usual telco protection plus that provided by the natural inductance of hybrid circuit and impedance matching devices. Antenna matching networks also provide a measure of protection against all but direct strikes. Again it should be noted that investigations conducted at the selected sites, all located in the highest thunderstorm incidence area, gave no history of outages directly attributable to lightning induced transients on control lines.

An additional change, No. 272 dated 11/22/77 (6), effectively reduced the requirement for installation of LPC's by deleting the requirement for RCAG facilities that have telco line automatic sensing and switching (LASS) equipment or at any other RCAG facility where landline inputs pass through telco solid state amplifiers at the RCAG facility before interfacing FAA equipment.

Unless more specific evidence of a need for protection for the RCAG develops, it is felt that no further action should be taken.

APPENDIX A

References

1. Cosei, R.M., "FAA Lightning Protection Study: Handbook of Installation Procedures for Selected Solid State Equipments," Report No. FAA-RD-77-170, October 1977.
2. Air Force Technical Manual, Service and Circuit Diagrams Transmitting Set, Radio, AN/GRT-21 and AN/GRT-22 T.O. 31R2-2GRT-102, 30 June 1971 and Change 4, 30 June 1973, International Telephone and Telegraph Corp. Aerospace/Optical Division. Also published as NAVELEX 0967-429-5010.
3. Air Force Technical Manual, Service and Circuit Diagrams, Receiver, Radio, AN/GRR-23 and AN/GRR-24, T.O. 31R2-2GRR-112, 31 August 1970, International Telephone and Telegraph Corp., Aerospace/Optical Division.
4. FAA-TI-6510.8 Preliminary Instruction Book, Voice Frequency Signaling System Type FA8187, Orbitronics Inc., Denver, Colo.
5. Department of Transportation, Federal Aviation Administration AF P 6500.1, CHG 234 dated 7/28/76, Subj: Communications Facilities and Equipment Modification Handbook-General, Chapter 279. Provide Lightning Surge Protection Circuits for Control Lines at Remote Center Air-to-Ground (RCAG) Facilities.
6. Revision to Reference 5, CHG 272 dated 11/22/77.